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Nanomechanical Testing in Materials Research and Development V

Proceedings

Fall 10-9-2015

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EXTRACTION OF CRYSTAL PLASTICITY PARAMETERS OF IN718 USING HIGH TEMPERATURE MICRO-COMPRESSION

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Ni-based superalloys are widely utilized in structural applications in aeroengine and power generation industries, owing to their exceptional high temperature mechanical properties in corrosive and oxidizing environments. Depending on the application fields, different types of superalloys with disparate microstructures are employed. For the turbine discs and some static components, forged or cast polycrystalline Ni-based superalloys are usually used. In the present investigation, site-specific micropillars with the diameter varying from 1 um to 18 um were milled out by Focused Ion Beam (FIB) from a polycrystalline IN718 superalloy specimen and then measured with high temperature micro-compression techniques up to 575 ºC. The effects of pillar size, pillar orientation, strain rate and temperatures on the micro-compression behavior were quantitatively assessed. The measurements show that there is a small size effect with the pillar diameter spanning from 3 μm to 18 μm, a large effect of crystal orientation on yield strength, a small strain rate sensitivity at room temperature and high temperature as well as a small yield strength drop when the testing temperature increases to 575 ºC. The different hardening behavior for single-slip, co-planar and non co-planar double slip as well as multiple-slip conditions were investigated. The micro-compression testing results were used to determine the crystal plasticity parameters of a phenomenological crystal plasticity (CP) model of IN718 superalloy, by comparing the experimental measurements with finite element (FE) simulations. The extracted crystal plasticity parameters were then used in a polycrystalline finite element model, in which the actual microstructure is explicitly accounted by a Representative Volume Element (RVE). This new model was able to predict, without fitting any parameter, the experimental macroscopic compression test with an error below 5%.

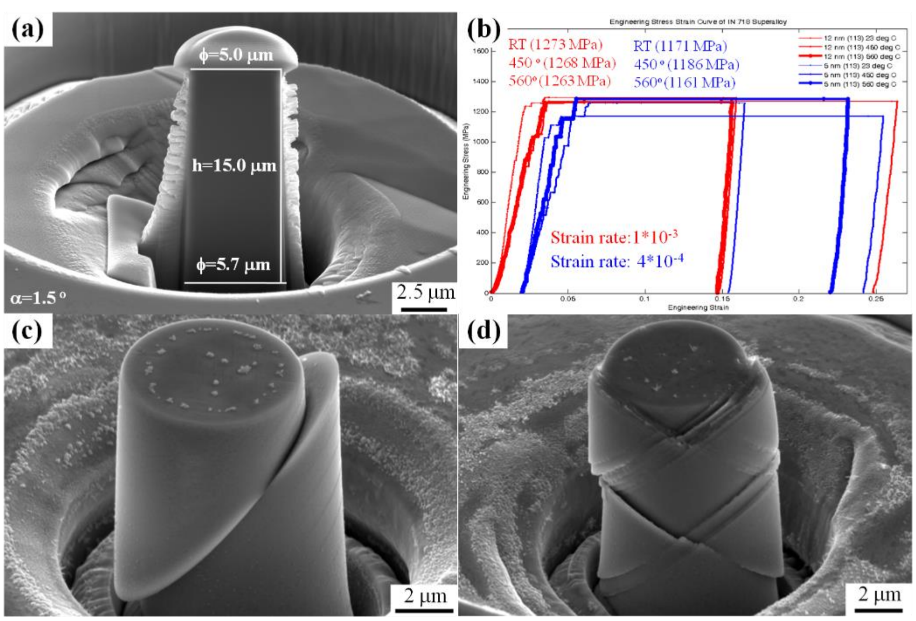

Figure 1 – (a) An undeformed micropillar was cut by FIB along the surface normal to measure the taper associated with annual milling method, and the taper is ~1.5 º. (b) Influence of strain rate on the microcompression results at room temperature, 450 ºC and 560 ºC with the same orientation. (c) Deformed morphology of a micropillar deformed in a single slip condition at 450 ºC. (c) Deformed morphology of a micropillar deformed in a double slip condition at 450 ºC.